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PII: S0045-7825(16)30319-X
DOI: http://dx.doi.org/10.1016/j.cma.2016.11.001
Reference: CMA 11211

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 5 May 2016
received in revised form 11 October 2016
accepted 2 November 2016

A Generic Contact Detection Framework for Cylindrical Particles in Discrete Element Modelling

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Abstract

This paper aims to develop a generic framework for detecting contact between cylindrical particles in discrete element modelling based on a full exploitation of the axi-symmetrical property of cylinders. The main contributions include: 1) A four-parameter based local representative system is derived to describe the spatial relationship between two cylinders so that the 3D cylinder-cylinder intersection problem can be reduced to a series of 2D circle-ellipse intersections, which considerably simplifies the contact detection procedure. 2) A two-stage contact detection scheme is proposed in which no-overlap contact pairs are identified in the first overlap check stage, and then the actual overlap region is determined in the second resolution stage and represented by two schemes: the layered representation which is generic, and the edge representation which is numerically more efficient but less accurate. 3) The most significant contribution is the development of two theorems that establish a fundamental relationship between the contact point and contact normal of two contacting cylinders, offering a simple approach to determining the normal direction based on the contact point and vice versa. These theorems are valid not only for cylinders, but also for any axi-symmetrical shapes and their combinations. Some numerical issues are discussed. Numerical examples are presented to illustrate the capability and applicability of the proposed methodologies.

KEYWORDS: Discrete element method, Cylindrical particle, Axi-symmetry, Non-spherical shape, Contact detection, Contact normal, Contact point

1 Introduction

The discrete element method (DEM) [1] has been firmly established as one of the most effective computational techniques for modelling systems exhibiting discrete or particulate behaviour in many scientific and engineering applications, especially in porous media, soil and geo-mechanics, agricultural and chemical engineering, pharmaceutical and material processing, to name a few. The success lies in its ability to model individual particle behaviour in the system concerned by effectively detecting possible physical contact on their boundaries, followed by evaluating the corresponding contact forces based on a set of contact interaction laws. Most of discrete element simulations that have been conducted so far employ circular or spherical particles, and problems with non-spherical particles are typically modelled by bonding or clumping spherical particles together to represent real non-spherical particles. There has been an increasing interest, particularly in industrial applications, in using non-spherical particle shapes as primitive discrete elements. Since the 1980s, there has been a

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